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EVALUATION OF MECHANICAL PROPERTIES OF TREATED HYBRID PARTICULATE REINFORCED POLYESTER COMPOSITES

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ABSTRACT

In recent years, natural fibers along with mineral fillers are being used to fabricate hybrid composites to achieve enhanced mechanical properties. In this paper, the fabrication and mechanical characterization of novel hybrid particulate reinforced polyester composites are presented. Also, the effect of treated hybrid particulate reinforced composites is investigated. In this work, groundnut shell powder (GSP) and silicon carbide (SiC) hybrid particulates are used as constituents in different volume fractions to fabricate six different composite specimens (three each with untreated and treated GSP) and hand layup process is used for fabrication of these composite specimens. The alkaline malic acid was used for surface treatment. The effect of hybrid particulates, on tensile, flexural and impact properties of the polyester composites were investigated with and without surface treatments. It is observed that alkaline treated composite at 30% volume fraction of hybrid particles resulted in improved mechanical properties and such composites can be used in low load bearing applications.

KEYWORDS: Groundnut Shell, Polyester Resin, SiC Filler & Alkali Malic Acid

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Original Article

1. INTRODUCTION

A composite material may be a non-uniform solid consisting of two or a lot of completely different materials that area unit automatically secure along. Every of the varied elements retains its identity in the composite and maintains its characteristic structure and properties. Generally, the structure of a composite consists of phases, matrix and reinforcement. The matrix may be a continuous part and therefore the reinforcement may be a discontinuous one. The duty of reinforcements is attaining strength of the composite and therefore the matrix has the responsibility of bonding of the reinforcements. The composite materials, however, usually possess combination of properties like stiffness, strength, weight, heat performance, corrosion resistance, hardness and physical phenomenon that aren't attainable with the individual components [1].

Natural fillers have become alternative reinforcement for synthetic fillers in polymer composites, due to their advantages like low density, less tool wear during processing, low cost, non toxic, easy to process, environmental friendly, and biodegradability. The natural filler containing composites are used in various applications like automobiles, aerospace, railway coaches, military applications, building and construction industries and ceiling paneling, partition boards, packaging, consumer products, etc. Beside their desired mechanical properties, their resistance to corrosion is additionally a tempting issue to use these composite in several

areas. Though they are sensitive to ultraviolet radiation light, heat and wetness environments, smart maintenance might increase their life time [2]. Natural fiber strengthened composites have gained right smart attention notably within the producing industry as a result of their light weight, corrosion resistance, abundance, and biodegradability. The alkaline treated and untreated groundnut shell powder (GSP) was used to reinforce cycled synthetic resin to provide GSP-recycled synthetic resin composites with improved mechanical properties and biodegradability [3]. The study on tensile properties of treated and untreated groundnut shell stuffed natural rubber composites show that the durability of the composite decreases with increase in fibre loading of the composites for each treated and untreated fillers (with highest worth < 10MPa), but their impact energy and hardness increased with filler loading [4]. In this work, the effect of hybrid particulates, on tensile, flexural and impact properties of the polyester composites were investigated with and without surface treatments.

2. MATERIALS AND METHOD

2.1. Materials

Groundnut shell particulate & SiC particulates were taken as hybrid reinforcement material in this investigation. The matrix material consists of polyester resin with Methyl Ethyl Ketone Peroxide as a catalyst and Cobalt octoate as accelerator were mixed in the ratio of 1:0.015:0.015. Alkaline malic acid was used for surface treatment of hybrid particulates. Polyester resins are the most widely used resin systems, particularly in the marine industry [5]. Groundnut shell is one of such natural agro waste filler used and it contains cellulose, hemicellulose and lignin. The hemicelluloses content of the fiber is found to be 18.7%, cellulose 35.7%; lignin 30.2% and ash content 5.9%. The use of groundnut shell particles to reinforce polyester resin has resulted in improvement in tensile strength and other mechanical properties [6]. Silicon carbide was the hardest synthetic material. It has Mohs hardness rating of 9. In addition to hardness, it has fracture characteristic that make them extremely useful in abrasive wheel. Its high thermal conductivity, together with high temperature strength, low thermal expansion and resistance to chemical reaction, makes silicon carbide is valuable in the manufacture of high temperature bricks and other refractory. It is also classed as a semiconductor, having an electrical conductivity between that of metals and insulating materials [7, 8].

2.2. Surface Treatment Process

Groundnut shell powder soaked in a malic acid solution for 1/2 hour. The fabrics were then washed several times with fresh water to remove any malic acid sticking to the fiber surface. Finally, washed with distilled water. Then the fibers were dried at room temperature for 30 mins. Malic acid is an organic compound with the molecular formula $C_4H_6O_5$. It is a dicarboxylic acid that is made by all living organisms, contributes to the pleasantly sour taste of fruits, and is used as a food additive. Malic acid has two stereoisomeric forms (L- and D-enantiomers), though only the L-isomer exists naturally. The salts and esters of malic acid are known as malates. The malate anion is an intermediate in the citric acid cycle.

2.3. Hand Layup Process

The hybrid composite materials are fabricated by hand layup process (Figure 1). A mold with dimension 300 × 300 × 3 mm is prepared. For various volume fractions of hybrid, particulate and resin stirred well with and poured into the mold. Care was taken to keep away from the air bubbles. As a matter of first importance, a discharge gel is splashed on the form surface to stay away from the adhering of polymer to the surface. Thin plastic sheets are utilized at the top and base of the mold plate to get great surface complete of the composite. The polymer is consistently spread with the assistance of

brush. In the wake of setting the plastic sheet, discharge gel is splashed on the inward surface of the mold plate which is then kept on the stacked layers and the weight is applied. In the wake of curing either at room temperature or at some particular temperature, mold is opened or the composite part is taken out and additionally handled to test the properties. Table 1 lists the composition of six composites fabricated.

Figure 1: The Hand Layup Process

Table 1: Composition of Composite Specimens

Sample No.	Composition of Composite			Surface Treatment
	Ground nut powder (%)	SiC (%)	Polyester resin (%)	
1	10	2	88	Untreated
2	20	2	78	Untreated
3	30	2	68	Untreated
4	10	2	88	Alkaline treated
5	20	2	78	Alkaline treated
6	30	2	68	Alkaline treated

3. RESULTS AND DISCUSSIONS

3.1. Tensile Testing

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. The commonly used specimen for tensile test is the dog bone shaped type. During the test, a uniaxial load is applied through both the ends of the specimen. The dimensions of specimen are 1650 × 12.5 × 3 mm (Figure 2). The tensile test is performed in the universal testing machine and results are analyzed to calculate the tensile strength of composite samples. This test is conducted as per ASTMD638 standard using UTM. Table 2 and Figure 3 present the tensile strengths obtained from tensile tests for different untreated and treated composite specimens under consideration.

Figure 2: Tensile Test Specimen

Table 2: Tensile Strength of Treated and Untreated Specimens

Sample No.	Composition of Composite			Surface Treatment	Tensile Strength (kN)
	Ground Nut Powder (%)	SiC (%)	Polyester Resin (%)		
1	10	2	88	Untreated	3.95
2	20	2	78	Untreated	3.6
3	30	2	68	Untreated	8.4
4	10	2	88	Alkaline treated	4.2
5	20	2	78	Alkaline treated	4.5
6	30	2	68	Alkaline treated	9.7

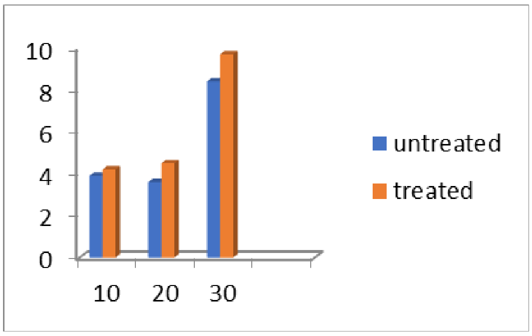

Figure 3: % of Hybrid Particulates vs. Tensile Strength in kN

From Figure 3, it can be observed that while comparing the tensile strengths of untreated hybrid composites, the hybrid composite with 30% ground nut powder results in maxium tensile strength of 8.4 kN. Similarly, when comparing the tensile strengths of treated hybrid composites, the hybrid composite with 30% nut powder results in maxium tensile strength of 9.7 kN. It indicates that addition of ground nut powder increases the tensile strength, as it is uniformly distributed in the matrix and it provides better bonding between filler and matrix. When comparing the results of untreated and treated hybrid composites, clearly the treated hybrid composites resulted in enhanced tensile strength as that of the untreated composites. The alkaline treated hybrid composite with 30% nut powder results in maxium tensile strength of 9.7 kN, which is 13.1% more than that of the untreated composite having same volume fraction.

3.2. Flexual Testing

Flexural strength is defined as a materials ability to resist deformation under load. The short beam shear tests are performed on the composites samples to evaluate the value of inter-laminar shear strength. It is a 3-point bend test, which generally promotes failure by inter-laminar shear. This test is conducted as per ASTM D790 standard using UTM. The dimensions of the specimen is 130 × 12.5 × 3 mm (Figure 4). Table 3 and Figure 5 present the flexural strengths obtained from flexural tests for different untreated and treated composite specimens under consideration.

Figure 4: Flexural Test Specimen

Table 3: Flexural Strength of Treated and Untreated Specimens

Sample No.	Composition of Composite			Surface Treatment	Flexural Strength (N)
	Ground nut Powder (%)	SiC (%)	Polyester Resin (%)		
1	10	2	88	Untreated	166.5
2	20	2	78	Untreated	72.9
3	30	2	68	Untreated	245.4
4	10	2	88	Alkaline treated	254.7
5	20	2	78	Alkaline treated	82.5
6	30	2	68	Alkaline treated	570.1

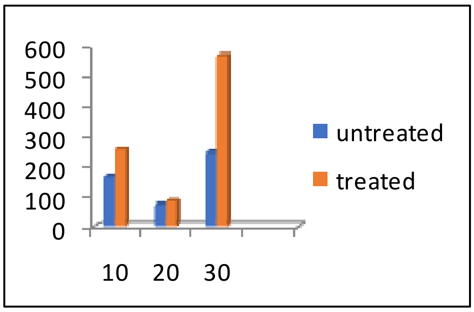

Figure 5: % of Hybrid Particulates vs. Flexural Strength in N

From Figure 5, it can be observed that while comparing the flexural strengths of untreated hybrid composites, the hybrid composite with 30% ground nut powder results in maxium flexural strength of 245.4 N. Similarly, when comparing the flexural strengths of treated hybrid composites, the hybrid composite with 30% nut powder results in maxium flexural strength of 570.1 N, which is 132.3% more than that of the untreated composite having same volume fraction. The strong interfacial bond was developed between particles and polyester matrix that tends to the transfer of flexural load in matrix.

3.3. Impact Testing

The impact properties of a material represent its capacity to absorb and dissipate energies under impact or shock loading. In practice, the impact condition may range from the accidental dropping of hand tools to high speed collisions, and the response of a structure may range from localized damage to total disintegration. The dimensions of specimen is 65.5 × 12.5 × 3 mm (Figure 6). This test is conducted as per ASTM D790 standard. Table 4 and Figure 7 present the flexural strengths obtained from flexural tests for different untreated and treated composite specimens under consideration.

Figure 6: Flexural Test Specimen

Table 4: Impact Strength of Treated and Untreated Specimens

Sample No.	Composition of Composite			Surface Treatment	Impact Strength (J)
	Ground nut Powder (%)	SiC (%)	Polyester Resin (%)		
1	10	2	88	Untreated	1.5
2	20	2	78	Untreated	1.5
3	30	2	68	Untreated	1.45
4	10	2	88	Alkaline treated	1.5
5	20	2	78	Alkaline treated	1.5
6	30	2	68	Alkaline treated	1.42

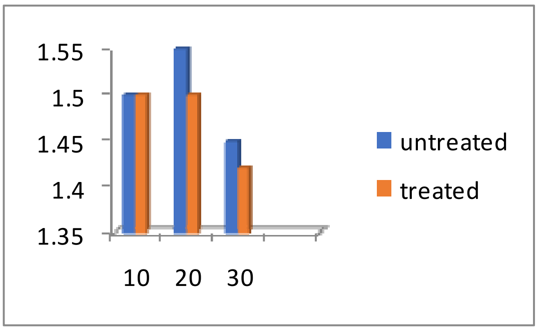

Figure 7: % of Hybrid Particulates vs. Impact Strength in J

From Figure 7, it can be observed that there is no significant effect of surface treatment on the impact strength of the composites, which is in contast to tensile and flexural strengths. The maxium impact strength of both treated and untreated hybrid composites is 1.5 J. The greater bonding of polyester resin with hybrid particulates exhibited better impact strength at 20 % volume fraction. Poor interfacial bonding between matrix and hybrid particulates resulted in decrease of impact strength at 30 % volume fraction.

4. CONCLUSIONS

In this work, the fabrication and mechanical characterization of novel hybrid particulate reinforced polyester composites were presented, and also the effect of treated hybrid particulate reinforced composites was investigated. The following conclusions can be drawn from this study.

- The tensile and flexural strength of the composites depend upon weight percentage of the filler material. The hybrid composite with 30% ground nut powder results in maxium tensile and flexural strengths.
- When comparing the results of untreated and treated hybrid composites, clearly the treated hybrid composites resulted in enhanced tensile and flexural strengths as that of the untreated composites.
- Unlike tensile and flexural strengths, there is no significant effect of surface treatment on the impact strength of the composites.

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